COMMONWEALTH OF VIRGINIA
Department of Environmental Quality
Division of Water Programs Coordination
Ellen Gilinsky, Ph.D., Director

Subject: Guidance Memo No. 04-2020
           Significant Figures for Discharge Monitoring Reports

To: Regional Directors

From: Ellen Gilinsky, Ph.D., Director

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Copies: Regional Water Permit Managers, Regional Water Compliance Managers, Amy
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Summary:

This memo clarifies the number of significant figures to be used in permits and to report
monitoring results on the Discharge Monitoring Reports (DMR). It applies only to permits
drafted or modified on or after the date of this memorandum. This guidance replaces Guidance
Memo No. 03-2008 (Significant Figures).

Electronic Copy:

An electronic copy of this guidance in PDF format is available for staff internally on DEQNET,
and for the general public on DEQ's website at: http://www.deq.virginia.gov/water/.

Contact information:

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Disclaimer:

**This document is provided as guidance and, as such, sets forth standard operating
procedures for the agency. However, it does not mandate any particular method nor does
it prohibit any particular method for the analysis of data, establishment of a wasteload
allocation, or establishment of a permit limit. If alternative proposals are made, such
proposals should be reviewed and accepted or denied based on their technical adequacy
and compliance with appropriate laws and regulations.**

Significant Figures for Discharge Monitoring Reports

For permits drafted or modified on or after the date of this memorandum, effluent limitations should generally be written using at least two significant figures taking into account the analytical methods approved to determine and report compliance. Where existing permit limits exceed two significant figures, it is not necessary to reduce the number of significant figures if an approved test method can accommodate the greater sensitivity/precision. There are several exceptions - (a) bacteriological limits, (b) acute and chronic WET endpoints, and (c) BOD only if a single digit effluent is to be required. Bacteriological and WET data are based on "counts" and therefore not subject to significant figure rules and the method for determining BOD is not accurate enough to provide data beyond a whole number.

Monitoring results reported on the Discharge Monitoring Report (DMR) should be reported to the accuracy of the test, which must be capable of reporting at least the same number of significant digits as the permit limit for a given parameter. Rounding the results to the number of significant digits in the permit, where the test method is sensitive enough to report more, is not acceptable and shall not be allowed. If there is not a method allowed by the permit that is accurate enough to measure two significant figures below the value of 1.0, it will be the permittees' responsibility to provide documentation demonstrating that only one significant figure can accurately be reported.

For numbers that do not contain decimal points, the trailing zeros may or may not be significant. For example, "10" may be considered to be either one or two significant figures. The problem with rounding of ambiguous numbers is pervasive enough to cause EPA to recently change the MCL for arsenic in drinking water from 10 ppb to 0.010 ppm. To avoid confusion with permit limits that are multiples of 10, either specify the number of significant figures in a footnote or express the limit in scientific notation. Two digit whole numbers should be footnoted and larger numbers that are multiples of 10 should be in scientific notation. [e.g., 10 should be footnoted with "Limit given is expressed in two significant figures."; 760,000 should be 7.6×10^5]

It is important to follow a number of accepted mathematical conventions in order to properly calculate limits and report monitoring results. The following rules for significant figures, rounding and precision apply to measured values, such as concentration, and not to counted values, such as number of days, colony counts or conversion factors.

Significant Figures:
Regardless of the measuring device, there is always some uncertainty in a measurement. Significant figures include all of the digits in a measurement that are known with certainty as well as the last digit, which is an approximation.

Rules for Significant Figures:
1.) All non-zero digits (1-9) are to be counted as significant.
2.) All zeros between non-zero digits are always significant. Both 4308 and 40.05 contain four significant digits.
3.) For numbers that do not contain decimal points, the trailing zeros may or may not be

significant. The number 470,000 may have two to six significant digits.
4.) For numbers that do contain decimal points, the trailing zeros are significant. Both 0.360 and 4.00 have three significant digits.
5.) If a number is less than 1, zeros that follow the decimal point **and** are before a non-zero digit are not significant. Both 0.00253 and .0670 contain three significant digits.

Rounding:
Rounding may be necessary to properly calculate values to be used for permit limits and to report results. All calculations (i.e. averaging and multiplying) should be performed prior to any rounding taking place. While several rounding conventions exist, rounding as stated in Part 1050 B of Standard Methods for the Examination of Water and Wastewater (18th, 19th and 20th ed.) is currently required for all methods found in that book. Those methods are frequently used for compliance monitoring. For consistency, DEQ should use these same rules (given below) for establishing permit limits, and encourage their use for reporting of all data.

Rules for Rounding
Examine the digit following (i.e., to the right of) the last digit to be reported. This digit is the one that is referred to as "being dropped" when rounding a number. Apply the following rules for rounding:
1.) If the digit being dropped is 1, 2, 3, or 4, leave the preceding number as it is. 20.3647 rounded to two significant figures, becomes 20.
2.) If the digit being dropped is 6, 7, 8, or 9, increase the preceding digit by one. 26.6462 and 26.9081, rounded to two significant figures, become 27 in both cases.
3.) If the digit 5 is being dropped, round off the preceding digit to the nearest even number (0 is considered an even number when rounding off): thus 2.25 becomes 2.2 and 2.35 becomes 2.4.

Example: Using two significant figures, 1048, 1053 and 1059 all round to 1000; 1060 rounds to 1100; 1153 rounds to 1200.

Precision:
Monitoring results should be reported with the same degree of precision that was achieved in the analysis/measurement of the value. This means that numbers resulting from calculations, including loadings, cannot be more precise than the raw data used in the calculations. Note: In cases where the permittee is allowed to treat a <QL as zero when averaging, that zero is to be considered as being "0.00".

Rules for Precision:
1.) For addition or subtraction, the answer can contain no more decimal places than the least precise measurement.
   13.681 - 0.5 = 13.181 should be rounded off to the tenths place, with a correct answer of 13.2
2.) For multiplication or division, the least number of significant figures in any of the measurements determines the number of significant figures in the answer.
   2.5 x 3.42 = 8.55 should be rounded off to two significant figures, with a correct answer of 8.6.

3.) Numbers such as conversion factors or number of days are counted numbers and are not considered when determining the number of significant figures or decimal places in the calculation.
4.) If both addition/subtraction and multiplication/division are used in a calculation, follow the rules for multiplication/division.

Example: Calculate the suspended solids mass loading.
               Permit limit: 75 kg/day, Q = 0.67 MGD, C = 10.5 mg/L
               3.785 kg/mg/L/MG = Unit conversion for one gallon of water to one liter.

               Q x C x Unit Conversion = Mass Loading
               0.67 x 10.5 x 3.785 = 26.627475 kg/day

Precision rule #2 applies.
The numbers 2 and 6 in the result, are the two significant digits.
The number 6 (in the tenths place) in the result, is rounded up. Increase the preceding digit by one. Enter 27 in the appropriate box.

Example: Calculate the 7-day average for ammonia
Permit Limit: 4.5 mg/L, sampled 4 times a week
               C = 0.56, 0.93, 2.53, 6.92 mg/L

$$\frac{0.56 + 0.93 + 2.53 + 6.92}{4} = 2.735 \text{ mg/L}$$

Precision rules # 3 and # 4 apply (Note: The 4 in the denominator is a counted value).
The numbers 2 and 7 in the result, are the two significant digits.
The number 3 (in the hundredths place) in the result, is rounded down. Leave preceding number as is. Enter 2.7 in the appropriate box.